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Animal Science

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Nyckelord: African elephant, Loxodonta africana, Corridor, Ol Pejeta Concervancy

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ABSTRACT

The African elephant (*Loxodonta africana*) has lost more than 50 % of its range to human civilisation. The remaining lands still used by the elephants are fragmented into smaller blocks with or without connection between them (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). The loss of available lands and the settlement of humans in previous elephant areas has resulted in conflict between the species. Elephants can destroy water supplies, ruin houses, raid and ruin crops and grain stores. They are also known to kill livestock and injuring or killing people. Elephants are hunted and killed both because these conflicts and because of their tusks that is sold as ivory on the black market (IUCN, 2011; IEF, 2014; IUCN Red List, 2015).

In order to protect the elephant population and minimise the conflicts with humans knowledge of elephant requirements and movements are crucial (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). In Africa there are many protected areas of varying sizes. Several of these protected areas are fences and some have wildlife corridors in their fences allowing different species to freely enter or exit the area. The aim of this study is to examine the elephant's usage and what influences the usage of the wildlife corridors in Ol Pejeta Conservancy in the Laikipia District, Kenya. Furthermore to evaluate the planned methods of data collection with camera traps at the corridors.

The elephants used the corridors frequently and their preferred time of traveling through the corridors were during the dark hours of the day when 60% of the passages were made. Single elephants used the corridors with a higher frequency than Family Groups and Adult Groups. A correlation of the corridor use and moon phase was found but no correlation with precip. The camera traps where used for collection of data on all animals using the corridors and therefore the cameras was set too low to give a clear view when elephants passed too close to the camera.

SAMMANFATTNING

Den Afrikanska elefanten (*Loxodonta africana*) har förlorat mer är 50 % av sitt utbredningsområde på grund av människan. De landområden som finns kvar av elefanternas ursprungliga utbredningsområde är fragmenterat i mindre områden (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). En del områden är sammanlänkade genom mindre partier vildmark medan vissa områden nästan är helt avskilda. Denna fragmentering och minskning av utbredningsområden för elefanterna har lett till konflikter mellan elefanter och människor. Elefanter kan förstöra vattencisterner, hus, plundra och förstöra odlingar samt sädesförråd. De kan även döda boskap och skada eller döda människor. Elefanter jagas och dödas både på grund av dessa konflikter och på grund av deras betar som säljs på den svarta marknaden (IUCN, 2011; IEF, 2014; IUCN Red List, 2015).

För att kunna bevara och skydda elefantpopulationen samt minska konflikterna med människor behövs kunskap om elefanters olika behov och deras förflyttningar (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). I Afrika finns det många skyddade områden av varierande storlek. Många av dessa är inhägnade, med eller utan viltpassager som tillåter vissa djurarter att fritt röra sig in och ut ur parken. Syftet med denna studie är att undersöka elefanternas användande, och vad som påverkar deras användande av dessa passager i Ol Pejeta reservatet, i Laikipia distriktet i Kenya. Även att utvärdera de planerade metoderna att samla in data med hjälp av kamerafällor vid parkens viltpassager.

Elefanterna färdades genom passagerna nästan dagligen och främst under dygnets mörka timmar då 60 % av passagerna gjordes. Ensamma elefanter använde passagerna oftare än familjegrupper och grupper med endast vuxna elefanter. En svag korrelation mellan passagerna och månens bana hittades men ingen korrelation med nederbörd. Att använda de befintliga kamerafällorna till att samla in data för elefanterna var inte helt optimalt eftersom kamerorna var placerade så att alla djur som passerar dokumenteras. Detta resulterade i att kamerorna satt för lågt för att kunna ge en optimal bild av elefanter.

INTRODUCTION

African elephants (*Loxodonta africana)* used to roam the whole African continent but are now confined to a much smaller range which is fragmented into even smaller blocks (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). Since 1979 the African elephants have lost 50 % of their range and can now be found in only 37 of Africa's more than 50 countries. The largest populations are found in southern, eastern and central Africa (IUCN, 2011; IEF, 2014; IUCN Red List, 2015).

In the early part of the 20th century the African elephant numbered between 3-5 million, now the population is down to between 400 000 and 500 000 individuals, mainly due to habitat loss and poaching. Poaching, habitat loss and habitat fragmentation are still the major threats to the African elephant (IEF, 2014; IUCN Red List, 2015).

The conservation of the African elephants has immense benefits for biodiversity and local communities. They are considered an "umbrella" and "keystone" species that contributes to achieving global biodiversity conservation objectives. They are also seen as a "flagship" species providing great opportunities that include; improved access to natural capital, improvements to social capital, improved livelihood opportunities, greater food security and reduced vulnerability to ecosystem degradation (IUCN, 2011; IUCN Red List, 2015). Since the elephants range has shrunk and become more fragmented with only between 20-30% of their habitat within protected areas the conflicts with humans are unavoidable. Given the current trend the conflicts are also increasing. In most areas the potential benefits are outweighed by the negative economic effects and destruction of livelihoods by some elephants (IUCN, 2011; IUCN Red List, 2015).

Many of Africa's protected areas are fenced, some have corridors in the fence that allows different species to enter or exit the protected area freely. The aim of this pilot study is to evaluate the planned methods for examining the corridor use by the elephants in Ol Pejeta Conservancy in the Laikipia District, Kenya. Furthermore, the aim is to illuminate and evaluate the use and the importance of the corridors for the elephants in Ol Pejeta Conservancy. This information may help in the conservation of elephants and minimizing the elephant human conflict.

Background

Ol Pejeta Conservancy

Ol Pejeta is an old cattle ranch turned into a private wildlife conservancy. It is a semi-arid area of 380 km^2 situated in northeast Kenya in the Laikipia District with Nanyuki as the closest town. The whole area is fenced in with three special-designed wildlife corridors that enables all species except rhinos to pass freely in and out of the conservancy. The corridors are situated on the northern side of the conservancy which borders to the greater ecosystem of Laikipia/Samburu district (Ol Pejeta Conservancy, 2015).

The African Elephant

African elephants are today the largest land-living mammal, an adult weighs around 4-7 tons and have a height between 2-4 meters (8-14 feet) (IEF, 2014). There are two known subspecies of African elephant; the Savannah elephant (*Loxodonta africana africana*) and the Forest elephant (*Loxodonta africana cyclotis*) (IUCN, 2011; IEF, 2014; IUCN Red List, 2015). There are genetic evidence suggesting a third subspecies (West African Elephant) or even more. However until further research have been conducted to support a re-classification the African elephant is still considered a single species (IUCN,

2011; IEF, 2014; IUCN Red List, 2015). The IUCN Red List assessment is therefore conducted for the single species including all populations, which has placed the African elephant (*Loxodonta africana*) as vulnerable. The current population trend is increasing even if there are variations between regions, in some areas the elephants are still declining due to poaching and habitat loss while in other parts they are increasing. They are categorized in Appendix 2 and some licensed trade is possible (IUCN, 2011; IEF, 2014; IUCN Red List, 2015).

Group constellations

African elephants live in so called fission-fusion societies which mean that the group composition can change within hours, days or seasons (Archie *et al*., 2005; Wittemyer *et al*., 2005; Archie & Chioy, 2012). Adult males generally live alone, Single Individual (S), while related adult females live in core groups, with normally between 1-20 adult females and their young, which we have defined in this study as a Family Group (FG). A core group can temporarily divide into smaller groups or join with other core groups to form a larger unit. Core groups that often fuse together are called bond groups and usually have close genetic relatedness. Bond groups that share the same or close home ranges are called clans (Archie *et al*., 2005; Archie & Chioy, 2012).

Adult males breed with females from across the entire population and can also temporarily join with a core or bond group. They can also form loosely attached male groups, what we define as Adult Groups (AG), that normally consist of between 2 and 6 males but they rarely spend more than 10 % of their time with another male (Archie & Chioy, 2012). The fission and fusion of the groups are influenced by different ecological factors such as season, food and water availability, predators and mating (Wittemyer *et al*., 2005; Western & Lindsay, 2008). The age composition of the core group is another factor that influence the fission and fusions since groups with older matriarchs are generally larger than groups lead by younger matriarchs (Wittemyer *et al*., 2005). Close genetic relationships between females seems important for elephants and may have a high influence on their reproductive success (Archie *et al*., 2005).

Range and movements

Elephant home ranges can vary in size from 15 to 3,700 square kilometres depending on the habitat, season and population (Viljoen, 1989b; Leggett, 2006; Kinahan *et al.*, 2007; de Beer & van Aarde, 2008; IUCN, 2011). Elephants also have a complex movement pattern within their home range with many home sectors linked together by travel corridors (Viljoen, 1989b; Douglas-Hamilton *et al*., 2005). Within each home sector the elephants have favourite core zones in which they spend most of their time while in that area (Douglas-Hamilton *et al*., 2005). Douglas-Hamilton *et al*. (2005) found in their study that on average the elephants had around half of their range in protected areas. The core zones were mainly in these protected areas while the travel corridors crossed unprotected areas. Furthermore, they noted that the elephants spent between 10 and 98 % of their time in the officially protected areas and while in the travel corridors they moved significantly faster compared to when in their home sectors. This behaviour of moving faster while in the travel corridors Douglas-Hamilton *et al*. (2005) named as streaking behaviour. This is in line with Jachowski *et al*. (2013) who also noted this streaking behaviour and that elephants used the travel corridors even in an elevated physiological state. The stressed elephants moved even faster while in the travel corridors compared to their speed when not stressed. This suggests that the corridor use is an essential aspect of elephant behaviour and important for the conservation of elephants.

The movements of the elephants are also influenced by season, fences, rainfall, moonlight, food and water availability (Viljoen, 1989b; Barnes *et al*., 2007; Western & Lindsay, 2008; Wittemyer *et al.,* 2008; Loarie *et al*., 2009; Gunn *et al*., 2013). On average elephants in wet landscapes move 3km/day while elephants in dry landscapes move 6km/day. In the dry season the elephants are more active during night while in the wet season they are more active during the day (Loarie *et al*., 2009). According to Viljoen (1989b), Western & Lindsay (2008) and Loarie *et al*. (2009) water availability, which is linked with precip, drives the seasonal movements of elephants and artificial water sources changes these movements. The artificial water sources allow elephants to increase the feeding pressure and over exploit areas that normally would be unobtainable for them during the dry season (Viljoen, 1989b; Van Aarde & Jackson 2007; Western & Lindsay, 2008; Loarie *et al*., 2009). Fences have a similar effect during the wet season because they hinder elephants to move freely and force them to "bunch-up" in specific areas which increases the pressure on these areas (Loarie *et al*., 2009). Other factors such as moon phase might also influence the movements of the elephants. Barnes *et al*. (2007) and Gunn *et al*. (2013) report that crop-raiding elephants are influenced by the moon, the elephants are more likely to raid crops during dark and rainy nights while they avoid the fields during bright moonlit nights.

Water

An elephant needs water every 2-4 days but usually drinks around 225 liters of water per day. This can sometimes be drunk during a single visit, each trunkful can contain between 4 and 8 liters. Elephants have an ability to smell water from a long distance and are able to dig wells with their tusks if necessary (Viljoen, 1989b; Sukumar, 2003; IUCN, 2011; IEF, 2014).

Feed

Elephants are mixed feeders that eat a wide variety of different food depending on the season (Barnes, 1982; Woolley *et al.*, 2011; Pretorius *et al*., 2012; Shannon *et al*., 2013). They eat everything from grasses, small plants, bushes, fruit, twigs, tree bark and roots. Depending on the season and plant availability elephants forage between 16 and 24 hours a day (Barnes, 1982; Woolley *et al.*, 2011; Pretorius *et al*., 2012; Shannon *et al*., 2013). During the wet season they eat more grass and during the dry season they eat mainly woody browse (Barnes, 1982; Woolley *et al.*, 2011; Pretorius *et al*., 2012; Shannon *et al*., 2013).

Tusks, Ivory and Poaching

Both male and female African Elephants have tusks (IUCN, 2011). The presence and length of the tusks is a heritable trait combined with the age since tusks continue to grow throughout an elephant's life (Whitehouse, 2002). The tusks are used socially as a weapon or as an instrument of display (IUCN, 2011). They are also used when foraging for example to dig for roots or pry bark of trees (Whitehouse, 2002; IUCN, 2011). Because of the ivory trade elephants are still being hunted in Africa. The poaching of elephants have increased in the last years and poachers select elephants with big tusks since this gives more ivory and a higher price on the black market (Jachman *et al*., 1995; Wasser *et al*., 2004; Kenya Elephant Forum, 2013).

Elephant and Human conflict

Humans are occupying more and more areas where elephants used to roam freely which results in conflict. Elephants can have a big negative and costly effect on local communities by crop-raiding, destroying water supplies, ruining houses and grain stores, killing livestock and injuring or killing people. Only in Kenya more than 200 people have been killed over the last 7 years (IUCN, 2011; IUCN

Red List, 2015). Often the cost for these conflicts greatly outweighs the potential benefits that elephants may have on biodiversity and in turn on society. Many of the elephants that are causing these disturbances and problems mentioned above are killed both by authorities and poachers (IUCN, 2011; IUCN Red List, 2015). The Kenya Wildlife authorities alone kill between 50 and 120 "problem" elephants each year (IUCN, 2011; IUCN Red List, 2015). To successfully protect and enable a positive view by the local communities on the African elephant the conflict with humans must be minimized and benefits maximized (IUCN, 2011).

Elephants in Ol Pejeta Conservancy

Since elephants have seasonal migration patterns and Ol Pejeta Conservancy have three wildlife corridors there is no permanent population of elephants but at any one time there can be up to 300 individuals in the conservancy (Ol Pejeta Conservancy, 2015). The Ol Pejeta Ecological Monitoring Unit are closely observing a few individuals known to break fences and raiding crops in the neighbouring farms. Some of these individual have had their tusks shortened which has reduced the fence breaking (Ol Pejeta Conservancy, 2015).

Aim of the study

The aim of the study was to:

- Evaluate the methods used.
- To analyse at what time elephants walk out of and into the conservancy.
- Examine if any of the two corridors are more frequently used.
- Estimate the frequency of corridor use by the different elephant categories; Family Group, Adult Group and Single.
- Examine if it is possible to determine if it is generally the same groups moving in and out of the conservancy.
- Examine if there is an indication that moon phase or weather influences the corridor use.

Hypothesis

- The elephants will mainly use the corridors during the darker hours of the day, in the evening, at night and early morning.
- There will be no difference between the two corridors.
- Adult Groups and Single elephants will use the corridors more frequently than Family Groups.
- It will generally be the same groups moving in and out of the conservancy.
- Moon phase will affect the movement of the elephants. The corridors will be used less during full moon.
- Weather will affect the use of the corridors. The corridors will be used less when rain has occurred than when dry.

MATERIALS AND METHODS

Study area

The study was conducted in Ol Pejeta Conservancy (0°00'N, 36°56'E) located in a semiarid bushed grassland in Laikipia district of central Kenya. The conservancy covers 380 km^2 and is closed off by an electric fence with 3 wildlife corridors that allow all animal species except rhinos to walk freely in and out of the conservancy. All corridors are situated on the north side of the area which borders to the larger Laikipia-Samburu district. The site is located on the equator which means that the variation in time of sunrise and sunset is insignificant, the dark hours occur between 7 pm to 6 am (19:00-06:00). The area receives low annual rainfall (600 to 800 mm annually) and most rainfall occurs during the rainy seasons in March-May and again in October-December (Ol Pejeta Conservancy, 2015).

Figure 1. Study area; Ol Pejeta Conceravancy, Laikipia district in central Kenya (© Siyabona Africa Travel)

Corridors

The three corridors are all periodically monitored by cameras and all have a sanded area on the inside of the conservancy to register animal tracks. These tracks are recorded every morning and then the sanded area is raked. Images were collected for a total of 78 days during two time intervals during 2014 and 2015. Corridor number 1 was under reconstruction during the first duration of the data collection and therefore excluded from the study. Each corridor had three cameras positioned and aimed at different angles.

Figure 2a. Corridor area (© Henriette Sernert)

Figure 2b. Corridor area (© Henriette Sernert)

Data collection

The data was collected with camera traps, Reconyx HC600 Hyperfire motion-activated cameras, at corridors 2 and 3. The cameras have an infrared beam that when broken activates the camera and a photo is taken, at night there is a flash. The detection range of the cameras are 24 m (80 ft), the detection angle is 40.3°, the field of view 40.7° and they have a trigger speed of 0.21 seconds (Rexonyx). The cameras were mounted in a metal camera box fasted on a metal rod that was pushed into the ground. The boxes where placed at an average height of around 80 cm (31.5 inches) above the ground and the cameras where positioned with different viewpoints to obtain as much coverage of the area as possible. We assume that the images provide a reliable index for the activity of the species occurring in the study area. The cameras at corridor 2 where operating between 2014-01-03 to 2014-02-15 (period 1) and between 2014-12-25 to 2015-01-27 (period 2), a total of 78 days. The cameras at corridor 3 where operating between 2014-01-03 to 2014-02-15 (period 1) and between 2014-12-26 to 2015-01-23 (period 2), a total of 73 days. The camera memory cards were emptied once a week and

downloaded to a computer by the Ol Pejeta staff. The pictures were then forwarded to the research group by Dropbox. All data were collected during the dry season. The track records were not used for this study only the pictures. The environmental data were assembled from local records for Nanyuki which we assume is representative for the study area.

Data analysis

The data were sorted by using Microsoft Excel 2007. Each identified passing was recorded, a passage was defined as an event where either a group or a single elephant walked in or out of the conservancy. A group was defined as all individuals passing the camera trap in the same direction within 10 minutes of each other. The events where divided into three different elephant categories: FG for Family Group including all groups containing adults and young, AG for Adult Group including all groups containing more than one adult but no young, and S for Single Individual.

The data registered for every event were; year, month, day, time of the first picture in the series, time of the last picture in the series, corridor number, elephant categories, direction (in/out), the number of individuals in the group and the sex of the individuals. All recordings had unknown as alternative.

Statistical analysis

Descriptive statistical analyses were conducted in Microsoft Office Excel 2007 and SPSS Statistics 22. The data with unknown direction was excluded for the analysis on in and out per hour but was included for all other analyses. The total number of registered groups were 268, of these 244 could be identified as going in or out. For the remaining 24 the direction was unknown.

To analyse activity patterns every 24 hour cycle was divided into night (N) 18:01-06:00 and day (D) 06:01-18:00. For the correlation analyses Spearman´s rang correlation test (rho) was used for categorical variables and Pearson Correlation for continuous variables. Comparison between categorical variables Chi-Square test was used. Mann-Whitney U was used for analysing the difference between the two corridors. Statistical significance was set at a p – value of ≤ 0.05. All p – values are two tailed.

RESULTS

During the total study period of 78 days there were 61 days with events, elephants passing through the corridors. The total number of events was 268. The elephants passed through the corridors mainly during dark hours. There was a peak of events at 19:00 when the sun starts to set and then another peak at around 01:00. The events lessen after this and reach a dip at around 03:00 in the morning (Figure 3).

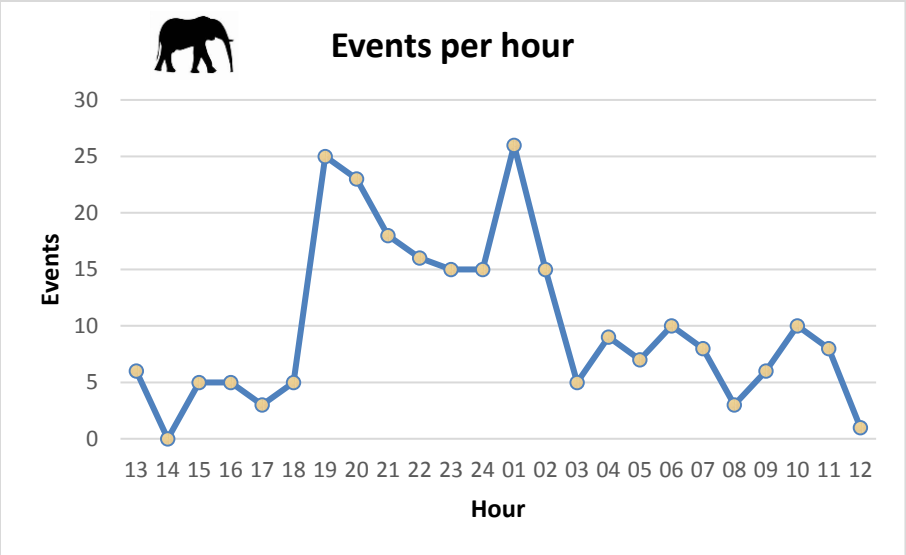


Figure 3. Events per hour

The direction of the events per hour shows that it is almost as many events with the direction in as out with 60 % of the events occurring between 19:00 and 03:00 (Figure 4 & Table 1).

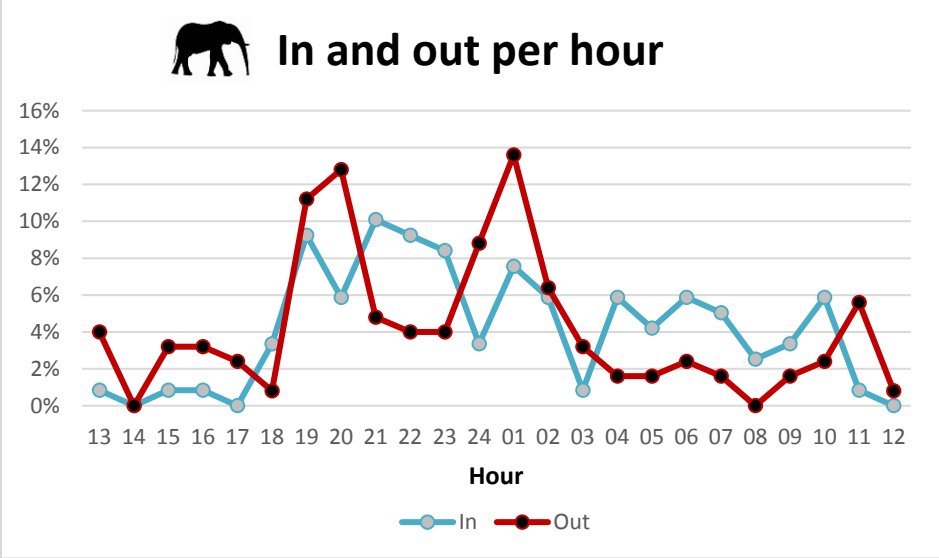


Figure 4. In and out per hour

Table 1. Distribution of in and out passages during day and night

Count	IN/OUT			
	Unknown	In	Out	Total
Day 06-18h	6	31	34	71
Night 18-06h	18	88	91	197
Total	24	119	125	268

Unknown: passage direction not identified

Figure 5a and 5b show a preference for corridor 2 but this was not statistically significant, p = 0.2.

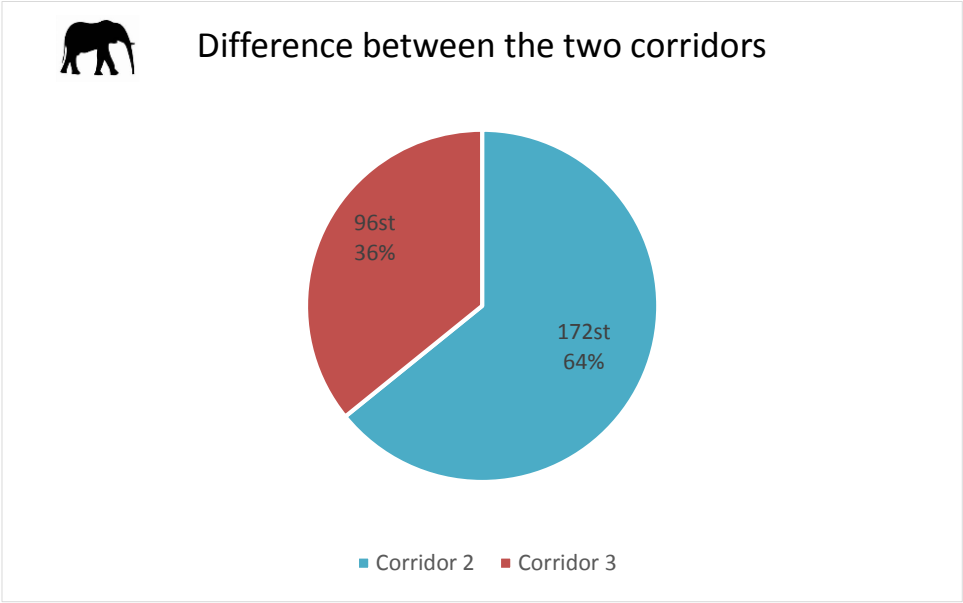


Figure 5a. Difference between the two corridors.

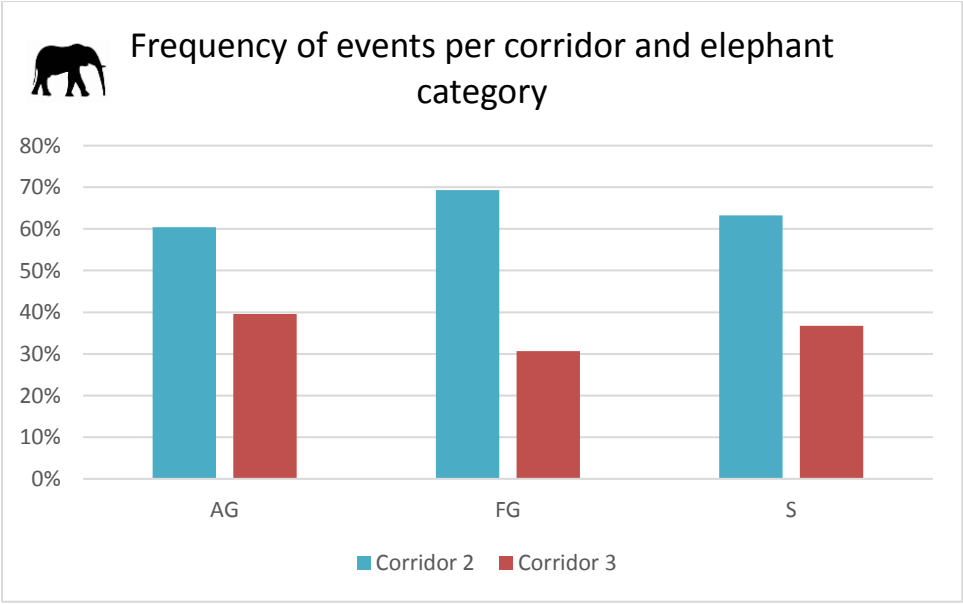
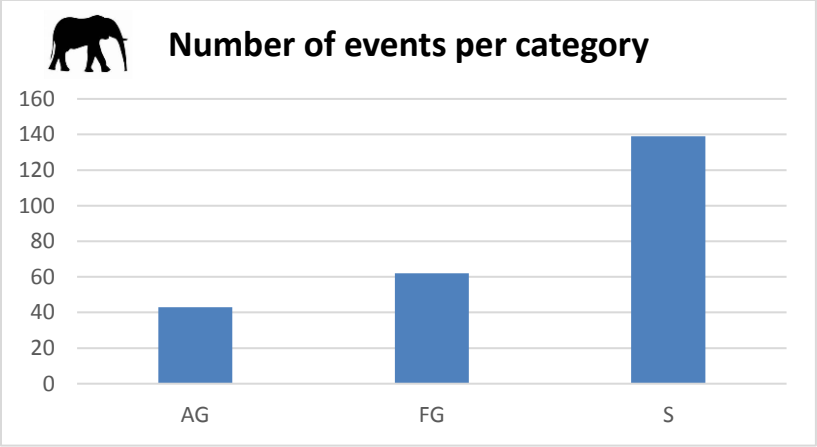


Figure 5b. Frequency of events per corridor and elephant category

Single Individual had most events when comparing the different elephant categories, Family Group came second and Adult Group had the lowest number of events (Figure 6).



AG: Adult Group
FG: Family Group
S: Single Individual

Figure 6. Number of events per category

A weak correlation was found in period 1 (Figure 7b) in terms of moon phase data but no correlation during period two (Figure 7c). Analysing the correlation of both periods revealed a rho = 0.35 and a p=0.002 (Figure 7a).

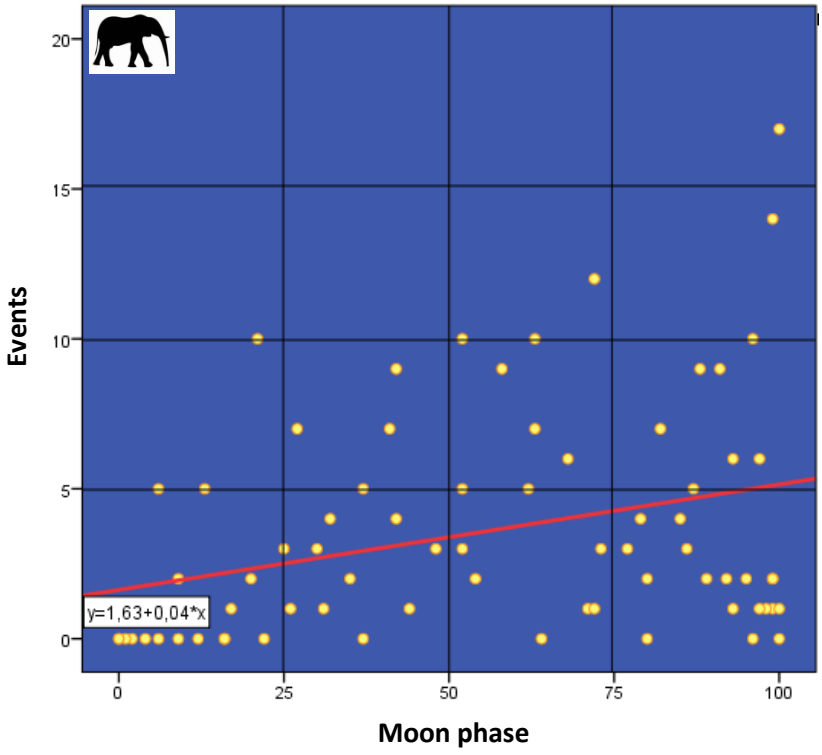


Figure 7a. Correlation of events with moon phase

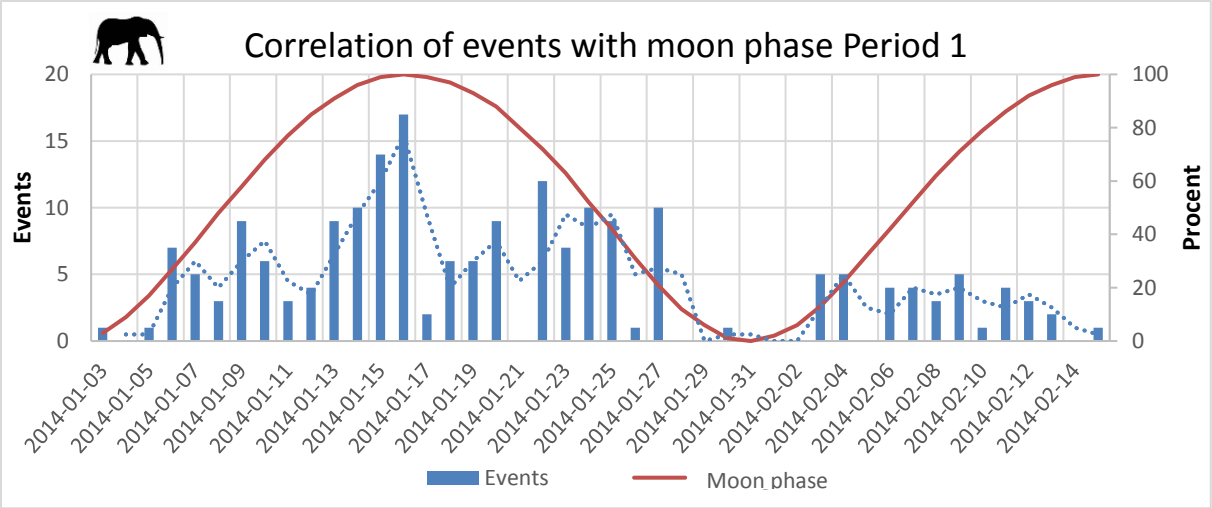


Figure 7b. Correlation of events with moon phase Period 1 (2014-01-03 to 2014-02-15)

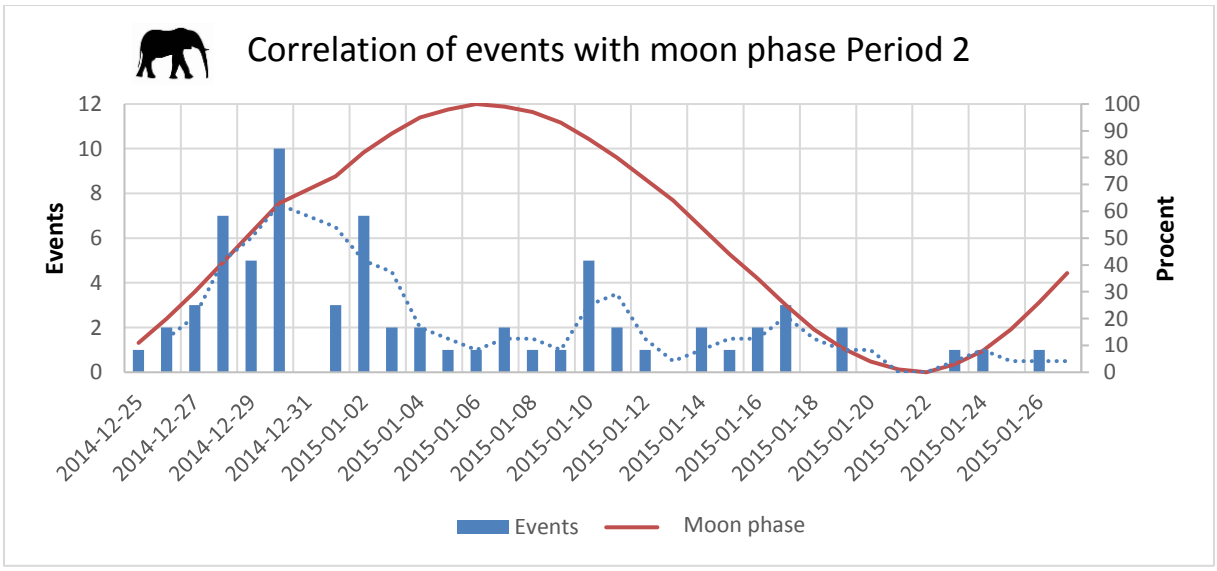


Figure 7c. Correlation of events with moon phase Period 2 (2014-12-25 to 2015-01-27)

The analysis of the correlation between precip and events showed no statistical significance and no correlation, -0.006, p = 0.96.

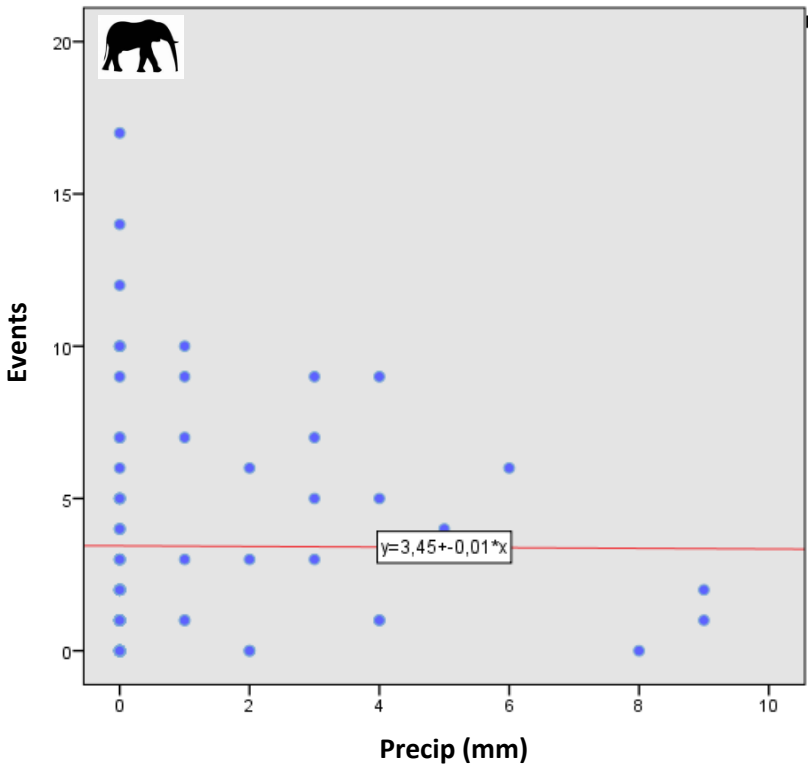


Figure 8. Correlation of events with precip.

DISCUSSION

Evaluation and discussion of the methods

A constructive and thorough evaluation of the methods used is important to keep an objective view of the data collected. It is also the key to improve and develop better methods for collecting relevant and reliable data. One of the aims in the present study was to evaluate the methods used in order to improve study protocols in the future.

The pictures taken by the camera traps were not optimal for observation of elephants. The cameras were set to detect all animal activity in the environment and thereby too low to be able to give a clear view of the elephants passing, sometimes only the legs could be seen. It was also difficult to get an accurate count of the number of individuals in a group since young calves or sub adults often were more or less blocked from view by a larger individual. This made it impossible to identify and name specific groups and individuals. The results of the present study suggest that some of the cameras should be mounted above the corridors in a high pole. This would give a more overall and complete view of the corridor area and make it possible to detect individuals hidden from the ground cameras view. One other suggestion is to do direct live observations at the time of the study in order to be familiar with the study population. This may facilitate reviewing of the pictures and identifying specific individuals or groups. Furthermore, live observation may give valuable information of the movement patterns of the different groups and confirm events caught on camera.

The detection range of the cameras was sometimes inadequate due to weather conditions, especially at night and in the early morning when it usually was misty. The morning dew together with the sun could also obscure the picture. To obtain a complete coverage of the corridor area the amount of cameras, the placement as well as different angles may improve the total number of high quality pictures.

At night the sounds or flash from the cameras altered the behaviour of the elephants and seemed at times to scare or aggravate them. This is in accordance with Meek *et al.* (2014) who reports that camera traps can both be heard, seen and smelled by animals. The detection of the camera depends on the species, their hearing range, vision and olfactory sensitivity (Meek *et al.*, 2014). Each time a photo is taken the camera produces a sound that is well within elephant hearing range (Heffner and Heffner, 1982; Meek *et al.*, 2014). At multiple occasions elephants stopped to examine the camera. Mostly they just touched the trap with their trunks but at a few occasions they pushed the camera trap so it started tilting. At one occasion the whole camera trap was lifted, smashed into the ground a couple of times and then thrown away, all this was recorded by the camera. If elephants perceive the cameras as something scary or dangerous they might avoid passing these corridors or pass at an elevated speed. New technology may offer cameras with high image quality and without flash, light or sound. This might reduce the attention of the elephants.

The manual collection of the pictures from the cameras memory card and the use of Dropbox were not optimal and not totally reliable. Pictures were lost in the transaction which made the data less trustworthy. It would be preferable to be at the site to collect the pictures and complete the camera monitoring with live observations. The optimal alternative would be if the data collection were saved directly to an internet account which would reduce the risk of the memory card getting full before

emptying. The tracks in the sanded area in front of the corridors could give valuable information as a complement to the pictures.

Elephants are mixed feeders and eat everything from grasses, small plants, bushes, fruit, twigs, tree bark and roots (Barnes, 1982; Woolley *et al.*, 2011; Pretorius *et al*., 2012; Shannon *et al*., 2013). To get feed samples from both inside and outside of the conservancy and evaluate if there is a difference in the nutrient values of the feed found inside the conservancy compared with the feed outside would give valuable information. Different desirable feeds would influence the elephants' use of the corridors. In addition faecal samples, both from inside and outside of the conservancy might give an indication if any special feed or nutrient outside of the conservancy is influencing the movement of the elephants.

Evaluation and discussion of the results

The results of the present study show that the elephants mainly walk through the corridors during night, between 19:00 and 03:00. This confirms the hypothesis and is in accordance with Loarie *et al*. (2009) who noted that elephants are mainly active at night during the dry season. The present study did not provide data from the wet season but in a future study it would be of interest to analyse if their movement pattern changes from the dry to the wet season and if they move more during the day in the wet season as noted by Loarie *et al*. (2009). Changes of movement patterns in different seasons are important information when designing strategies to lessen the conflicts between humans and elephants as well as when designing conservancies and to lessen the risk of poaching.

There was a difference in frequency of passages between the two corridors but no explanation to why the elephants preferred corridor no 2. However, the difference was not statistically significant. It would be of interest to compare the use of all three corridors together with information about the cameras positions, human settlements, vegetation and water sources in contrast to the location of the three corridors. This information can give an explanation on what influences the elephant's choice of corridor.

There was a difference in corridor use by the different elephant categories were Single Individual passed through the corridors more frequently than the other two categories. Unexpectedly Family Groups passed through the corridors with a higher frequency than the adult groups. This contradicts the hypothesis based on the idea that Ol Pejeta would be considered as a "safe place" especially by family groups. Ol Pejeta has multiple artificial waterholes and a variety of vegetation. The area is fenced and has guards patrolling the area to minimize poaching. Moreover the conflict between humans and elephants are low inside the conservancy. This is similar to the description done by Wittemyer (2001) who defines Samburu and Buffalo Springs National Reserves as a "safe haven" for the elephants in that area. Therefore the hypothesis was built on the same theory for Ol Pejeta and that female groups with young calves would more likely choose to stay inside Ol Pejeta to minimize risk to their young. On the other hand there are other dangers in Ol Pejeta for example they have a current population of 72 lions (Ol Pejeta Conservancy, unpubl. data, 2015). Generally elephants are safe against predation by large carnivores because of their large size and tight social system where family members and especially calves are well protected through an aggressive defence (Loveridge *et al*., 2006). Still there are occasions when calves are killed by lions and these kills are correlated with rainfall, more calves are killed during the dry season. Overall calf mortality is higher during drought periods (Williamson, 1975; Dunham, 1988; Dudley *et al.*, 2001; Loveridge *et al*., 2006). No elephant

calves have been reported killed by lions in Ol Pejeta during the study period, but the presence of the high number of lions can be a stressor affecting the behaviour and use of the corridors by the elephants in Ol Pejeta.

The main reason for the elephants' more or less daily treks outside the conservancy is suggested to be food since water sources is in abundance inside the conservancy. Whether they are searching for food in general or if they are looking for a specific food source not available in the conservancy is an open question. Further studies are needed with focus on feed inside and outside of the conservancy in contrast to elephant's nutrient needs. One explanation is that the elephants have overexploited the vegetation within Ol Pejeta which is a well-known risk with the occurrence of artificial waterholes (Viljoen, 1989a; Smit *et al.*, 2007a, & b; de Beer & van Aarde 2008; Tomas *et al.*, 2008; Loarie *et al*., 2009) and therefor need to venture outside the conservancy in search for food. The elephants may not even have been in Ol Pejeta during the dry season if it were not for the artificial waterholes since these seem to alter the movement patterns of elephants (Viljoen, 1989a; Smit *et al.*, 2007a, & b; de Beer & van Aarde 2008; Tomas *et al.*, 2008; Loarie *et al*., 2009).

The difference between the groups in the use of the corridors could most likely occur because of fewer Adult Groups than Family Groups. With the pictures alone it was not possible to mark specific groups or individuals. The total number of groups within each category remained unknown making the comparison more difficult. When in Ol Pejeta preparing for the study a few elephant groups and lone individuals where seen. These random observations during the light hours where short, few and not documented. Altogether, this made it not possible to mark and recognise the different groups or individuals. There are indications that one large family group that was viewed walking to one of the waterholes in the park was the same as seen in the pictures from the corridor cameras but this could not be confirmed. The fission and fusion mentioned by Wittemyer *et al*. (2005), Archie *et al*. (2005) and Archie & Chioy (2012) of different groups and individuals make the marking of specific groups' even more difficult using camera pictures alone. According to Archie & Chioy (2012) Adult Groups most often consists of a few males, between 2 and 6 individuals, with loose bonds that spend very little of their time together. It could therefore be assumed that there are fewer Adult Groups than Family Groups. The Single Individuals are perhaps not always observed as a Single individual, at different occasions they may temporarily join a Family Group or fuse together and form an Adult Group. Marking matriarchs and adult males with GPS collars would give a clearer picture of the fission and fusion between and among categories. The registration from a GPS would give more reliable information of movement patterns and frequency in which the different categories use the corridors. More data on the fission and fusion would be needed and a comparison between seasons since the herds are larger during the wet season than compared to the dry season (Wittemyer *et al*., 2005; Western & Lindsay, 2008). During the dry season dominant groups occupy in greater occurrence the preferred habitats, the habitats with plenty of food and water sources. The subordinate groups are forced to less desirable areas during this season and need to spend more energy searching for water and food (Wittemyer *et al*., 2007). Information about the rank, if they are dominant or subdominant, for each group that occupy Ol Pejeta during the dry season will give valuable information of how desirable Ol Pejeta is, whether or not it is a preferred habitat during the dry season. Moreover, this would give information on how the elephants values the food and water within Ol Pejeta. This information could also be complemented with feed samples to give a complete evaluation of the feed and nutrient availability within Ol Pejeta.

The streaking behaviour described by Douglas-Hamilton *et al*. (2005) and Jachowski *et al*. (2013) is not examined in the present study. However, a difference in movements was seen when comparing the pictures from the corridors with the random live observations in the park during the preparation of the study. The general impression form the camera pictures was that they had a higher speed when going through the corridors than compared to the live observations when the elephants where walking toward one of the parks water wholes. However, this has not been verified, but further studies could include measurement of their average speed when going through the corridors compared to when they are walking in the park. A higher speed when going through the corridors does not necessarily mean that the elephants experience or are aware of dangers outside of the conservancy as is suggested by Douglas-Hamilton *et al*. (2005) and Jachowski *et al*. (2013). The higher speed could mean that there is nothing of interest in between the two places the elephants are travelling. It is not possible to determine the reason for the higher speed when elephants move through travelling corridors as they use the traveling corridors even at an elevated state. One explanation is that they do not experience the traveling as something equal to danger. The corridors are important to the elephants but to which extent still have to be determined.

Analysing the pictures did not make it possible to ensure that it was the same individuals moving in as out of the conservancy. The main reason is that the cameras sometimes did not capture the whole herd or the whole individual. Some photos only revealed the legs of the elephant, the sun together with morning dew obscured the picture or the quality of the picture was too poor to be able to recognise a herd or a specific individual. Including more cameras at different positions and angles may improve the data collection and quality of the photos. Analysing several photos from the same area but from different angles would make it possible to view the whole situation and register the number of elephants as well as their direction. Additionally to do continuous live observations at the conservancy will optimise the data collection and thereby the analysis. However, live observations are time consuming and expensive, and not always possible to implement. Elephants are migratory (Viljoen, 1989b; Douglas-Hamilton *et al*., 2005; Leggett, 2006; Kinahan *et al.*, 2007; de Beer & van Aarde, 2008; Loarie *et al*., 2009; Jachowski *et al*., 2013) which results in new groups or individuals either leave or enter the conservancy at any time of the year and join with already existing herds (Wittemyer *et al*., 2005; Archie *et al*., 2005; Archie & Chioy, 2012). Using different markings on bulls and matriarchs will make it possible not only to identify separate individuals, but also give information of each elephants moving pattern. GPS collaring are used in many studies of wild elephants (Douglas-Hamilton *et al*., 2005; Loarie *et al*., 2009; Jachowski *et al*., 2013) but in order to mount the GPS on the animal sedation is needed which is stressing for both the animal and other members of the heard. Furthermore, the experience and stress related to the sedation may affect the behaviour and movement pattern of the elephants. Elephants are self-aware and can recognise new markings on their body (Plotnik *et al*., 2010) and a marking or GPS-collar might affect the behaviour of the individual waring it or other individuals in the herd.

Information if the same individuals and herds are walking in as out of the conservancy is necessary to understand the use of the corridors. To be able to follow the elephants during a longer period will give an overall view of the life of the elephants, how much time they spend inside compared to outside the conservancy, and where they prefer to spend their time during the nights and the days. The elephants move in and out of the conservancy during the whole day and night but the events increase during the evening, night and early morning. It would therefore be of interest to see if it is the same individuals

moving out and then in again during the same day or if they spend longer time than a few hours outside the conservancy.

Moon phase had a minor effect on the movement of the elephants, the analysis gave a correlation of a rho = 0.35 and a p=0.002 (Figure 6c). This is a weak correlation and other factors probably influence the movements of the elephants. The elephant's movements during the second period is in line with the hypothesis and with the studies of Barnes *et al*. (2007) and Gunn *et al*. (2013) while the data from the first period is in contrast. The difference in results could be due to the fact that the present study did not focus on crop-raiding elephants or that the goal for our elephants was not crop fields. In the present study weather conditions such as cloudiness and rainfall was not taken into account when analysing the moons influence on the elephants movements. This might also effect the results of the present study. However, it would be of interest to investigate if the presence of clouds and to what degree they cover the moon influence the elephants in Ol Pejeta and their movement pattern. Other aspects to consider and of interest to analyse in future studies are the difference between the dry season and the wet season. If the moons influence vary during the crop-growing season (April-August) (Barnes *et al*., 2007) and the rest of the year.

The analysis of the weather data showed no correlation but the most rain that occurred during the study period was less than 20 mm which might not have a very great effect on an animal that drinks over 200 litres a day (Viljoen, 1989b; Sukumar, 2003; IUCN, 2011; IEF, 2014). It would be of interest to investigate if the precip during the wet season will influence the corridor use. Then compare the corridor use in the wet season with the dry season since there is a general difference in movements between the two seasons (Viljoen, 1989b; Western & Lindsay, 2008; Wittemyer *et al.,* 2008; Loarie *et al*., 2009). Additionally, it would be of interest to evaluate whether this seasonal movement applies for a conservancy with multiple artificial waterholes that provides water year round. Whether the elephant density in Ol Pejeta is influenced by the two seasons. Artificial waterholes that provide a constant water source can together with protection lead to an increasing population and with that a higher pressure on local vegetation (Van Aarde & Jackson 2007; Western & Lindsay, 2008; Loarie *et al*., 2009). If the pressure on the vegetation gets to high this might lead to forced migration of the elephants or longer treks outside the conservancy to areas with more and better feed. According to Thouless (1995) the elephants of the Samburu-Laikipia districts started a seasonal migration from Samburu to Laikipia in the 1970s and before where more or less permanently residing in Samburu. The reason for the new migration is suggested to be the change of vegetation from grassland to bushland together with increasing permanent water sources in the Laikipia district. Samburu also had an increase in poaching during this time which might have influenced the elephant movements (Thouless, 1995). Some time has passed sense the 1970s and many things have changed, but have the elephants migration pattern changed with the human development in the area? If the elephants have found new areas to migrate to or if they are too confined to find enough food and therefore are more or less forced to raid farms for their crops.

The present study has both strengths and weaknesses. The study group were familiar with the area and had observed some of the elephants when in the park. The observations of the elephants' usage of the parks wildlife corridors are unique. No other study has been found examining this usage. The events registered where few and collected during two short periods in the same season. There were a lack of continuity in the collected data and many of the pictures had to be discarded because of the

quality. This might affect the outcome of the statistical analyses. A longer and more complete data collection might give other results compared to the results presented in the present study.

The future of the African elephant and many other beautiful animals are threatened by the development and expansion of human society. In order to ensure the survival of our worlds different animal species and a peaceful coexistence between us, knowledge of these different species are needed. The knowledge about their behaviour and special needs in order to provide protected areas with the resources and management needed by the specific species. The present study is hoped to lead the way for future studies about the African elephants, their need and usage of wildlife corridors and what influences these movements.

CONCLUSIONS

The corridors where frequently used by all the different elephant categories, Single, Adult Group and Family Group. There where elephants traveling through the corridors almost every day of the study period which indicate that the corridors are important to the elephants. The preferred time of traveling through the corridors where during the darker hours when 60% of the passages where made. The use of the corridors had a weak correlation with moon phase but no correlation was found with precip.

The camera traps at the corridors where used to collect data from all animals using the corridors and therefore where set too low to give an optimal view of the elephants passing. A longer study with camera traps adapted for elephants would give more reliable results.

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REFERENCES

ARCHIE, E.A., and CHIOY, P.I. 2012. Elephant behaviour and conservation: social relationships, the effects of poaching, and genetic tools for management. *Molecular Ecology*. 21, 765-778.

ARCHIE, E.A., MOSS, C.J., and ALBERTS, S.C. 2005. The ties that bind: genetic relatedness predicts the fission fusion of social groups in wild African elephants. *Proceedings of the Royal Society B*. (2006). 273, 513-522.

BARNES, R.F.W. 1982. Elephant feeding behaviour in Ruaha National Park, Tanzania (*Loxodonta africana*). *African Journal of Ecology*. 20:2, 123-136.

BARNES, R.F.W., DUBIURE, U.F., DANQUAH, E., BOAFO, Y., NANDJUI, A., HEMA, E.M., and MANFORD, M. 2006. Crop-raiding elephants and the moon. *African Journal of Ecology*. 45, 112-115.

DE BEER, Y., and VAN AARDE, R.J. 2008. Do landscape heterogeneity and water distribution explain aspects of elephant home range in southern Africa´s arid savannas? *Journal of Arid Environments*.

DOUGLAS-HAMILTON, I., KRINK, T., and VOLLRATH, F. 2005. Movements and corridors of African elephants in relation to protected areas. *Naturwissenschaften*. 92, 158-163.

DUDLEY, J.P., CRAIG, G.C., GIBSON, D.S.S, HAYNES, G., and KLIMOWICZ, J. 2001. Drought mortality of bush elephants in Hwange National Park, Zimbabwe. *African Journal of Ecology.* 39, 187-194.

DUNHAM, K.M. 1988. Demographic changes in the Zambezi Valley elephants. *Journal of Zoology.* 215, 382-388.

GUNN, J., HAWKINS, D., BARNES, R.F.W., MOFULU, F., GRANT, A.G., and NORTON, G.W. 2013. The influence of lunar cycles on crop-raiding elephants; evidence for risk avoidance. *African Journal of Ecology.* 52, 129-137.

HEFFNER, R., and HEFFNER, H. 1982. Hearing in the elephant (*Elephas maximus*). *Journal of Comparative and Physiological Psychology*. 96:6, 926-944.

IEF International Elephant Foundation. 2014. https://elephantconservation.org/elephants/african-elephants/, used 2016-01-22.

IUCN International Union for Conservation of Nature, Species Survival Commission (SSC), African Elephant Specialist Group (AfESG). 2011. http://www.african-elephant.org/index.html, used 2014-04-27.

IUCN Red List of Threatened Species. 2015. http://www.iucnredlist.org/details/12392/0, used 2016-01-22.

JACHMAN, H., BERRY, P.S.M., and IMAE, H. 1995. Tusklessness in African elephants: a future trend. *African Journal of Ecology*. 33:3, 230-235.

JACHOWSKI, D.S., SLOTOW, R., and MILLSPAUGH, J.J. 2013. Corridor use and streaking behaviour by African elephants in relation to physiological state. *Biological Conservation*. 167, 276-282.

KENYA ELEPHANT FORUM. 2013. The Ivory Trade and Elephant Poaching. Fact Sheet 02-2013.

KINAHAN, A.A., PIMM, S.L., and VAN AARDE, R.J. 2007. Ambient temperature as a determinant of landscape use in the savanna elephant, *Loxodonta africana. Journal of Thermal Biology.* 32, 47-58.

LEGGETTE, K.E.A. 2006. Home range and seasonal movement of elephants in the Kunene Region, northwestern Namibia. *African Zoology*. 41:1, 17-36.

LOARIE, S.R., VAN AARDE, R.J., and PIMM, S.L. 2009. Fences and artificial water affect African savannah elephant movement patterns. *Biological Conservation*. 142, 3086-3098.

LOVERIDGE, A.J., HUNT, J.E., MURINDAGAMO, F., and MACDONALD, D.W. 2006. Influence on drought on predation of elephant (*Loxodonta africana*) calves by lions (*Panthera leo*) in an African wooded savannah. *Journal of Zoology*. 270, 523-530.

MEEK, P.D., BALLARD, G.A., FLEMING, P.J.S., SCHAEFER, M., WILLIAMS, W., and FALZON, G. 2014. Camera traps can be heard and seen by animals. *http://journals.plos.org/*.

OL PEJETA CONSERVANCY. 2015. http://www.olpejetaconservancy.org/wildlife/wildlife-habitats/elephants/, used 2016-01-22.

PLOTNIK, J.M., DE WAAL, F.B.M., MOORE, D., and REISS, D. 2010. Self-recognition in the Asian Elephant and future directions for cognitive research with elephants in zoological settings. *Zoo Biology.* 29, 179-191.

PRETORIUS, Y., STIGTER, J.D., DE BOER, W.F., VAN WIEREN, S.E., DE JONG, C.B., DE KNEGT, H.J., GRANT, C.C., HEITKÖNIG, I., KNOX, N., KOHI, E., MWAKIWA, E., PEEL, M.J.S., SKIDMORE, A.K., SLOTOW, R., VAN DER WAAL, C., VAN LANGEVELDE, F., and PRINS, H.H.T. 2012. Diet selection of African elephant over time shows changing optimization currency. *Oikos*. 121, 2110-2120.

RECONYX. 2015. www.reconyx.com, used 2016-01-22.

SHANNON, G., MACKEY, R.L., and SLOTOW, R. 2013. Diet selection and seasonal dietary switch of a large dimorphic herbivore. *Acta Oecologica*. 46, 48-55.

SIYABONA AFRICA TRAVEL. 2016. http://www.kenyasafari.com/ol-pejeta-bush-camp_map.html, used 2016-05-08.

SMIT, I.P.J., GRANT, C.C., and DEVEREUX, B.J. 2007a. Do artificial waterholes influence the way herbivores use the landscape? Herbivore distribution patterns around rivers and artificial surface water sources in a large African savanna park. *Biological Conservation.*136, 85-99.

SMIT, I.P.J., GRANT, C.C., and WHYTE, I.J. 2007b. Elephants and water provision: what are the management links? *Diversity and Distributions.* 13, 666-669.

SUKUMAR, R. 2003. The living elephants: Evolutionary ecology, behavior, and conservation. New York. Oxford University Press.

THOULESS, C.R. 1995. Long distance movements of elephants in northern Kenya. *African Journal of Ecology*. 33:4, 321-334.

TOMAS, B., HOLLAND, J.D., and MINOT, E.O. 2008. Elephant (*Loxodonta africana*) home ranges in sabi sand reserve and Kruger National Park: a five-year satellite tracking study. *PLoS ONE.* 3(12), e3902.

VAN AARDE, R.J., and JACKSON T.P. 2007. Megaparks and metapopulations: Addressing the causes of locally high elephant numbers in southern Africa. *Biological Conservation.* 134, 289-297.

VILJOEN, P. 1989a. Habitat selection and preferred food plants of a desert-dwelling elephant population in the northern Namib Desert, South West Africa/Namibia. *African Journal of Ecology.* 27, 227-240.

VILJOEN, P. 1989b. Spatial distribution and movements of elephants (*Loxodonta africana*) in the northern Namib Desert region of the Kaokoveld, South West Africa/Namibia. *Journal of Zoology.* 219, 1-19.

WASSER, S.K., SHEDLOCK, A.M., COMSTOCK, K., OSTRANDER, E.A., BENEZETH, M., and STEPHENS, M. 2004. Assigning African elephant DNA to geographic region of origin: Applications to the ivory trade. *Proceedings of the National Academy of Science of the United States of America (PNAS)*. 101:41, 14847-14852.

WESTERN, D., and LINDSAY, W.K. 1984. Sesonal herd dynamics of savanna elephant population. *African Journal of Ecology.* 22:4, 229-244.

WHITEHOUSE, A.M., 2002. Tusklessness in the elephant population of the Addo Elephant National Park, South Africa. *Journal of Zoology*. 257:2, 249-254.

WILLIAMSON, B.R. 1975. Seasonal distribution of elephant in Wankie National Park. *Arnoldia (Rhodesia)*. 7,1-16.

WITTEMYER, G. 2001. The elephant population of Samburu and Buffalo Springs National Reserves, Kenya. *African Journal of Ecology.* 39, 357-365.

WITTEMYER, G., DOUGLAS-HAMILTON, I., and GETZ, W.M. 2005. The socioecology of elephants: analysis of the processes creating multitiered social structures. *Animal Behaviour*. 69, 1357-1371.

WITTEMYER, G., GETZ, W.M., VOLLRATH, F., and DOUGLAS-HAMILTON, I. 2007. Social dominance, seasonal movements, and spatial segregation in African elephants: a contribution to conservation behaviour. *Behavioural Ecology and Sociobiology*. 61:12, 1919-1931.

WITTEMYER, G., POLANSKY, L., DOUGLAS-HAMILTON, I., and GETZ, W.M. 2008. Disentangling the effects of forage, social rank, and risk on movement autocorrelation of elephants using Fourier and wavelet analyses. *Proceedings of the National Academy of Sciences.* 105, 19108.

WOOLLEY, L-A., PAGE, B., and SLOTOW, R. 2011. Foraging strategy within African Elephant family units: Why body size matters. *Biotropica.* 43:4, 489–495